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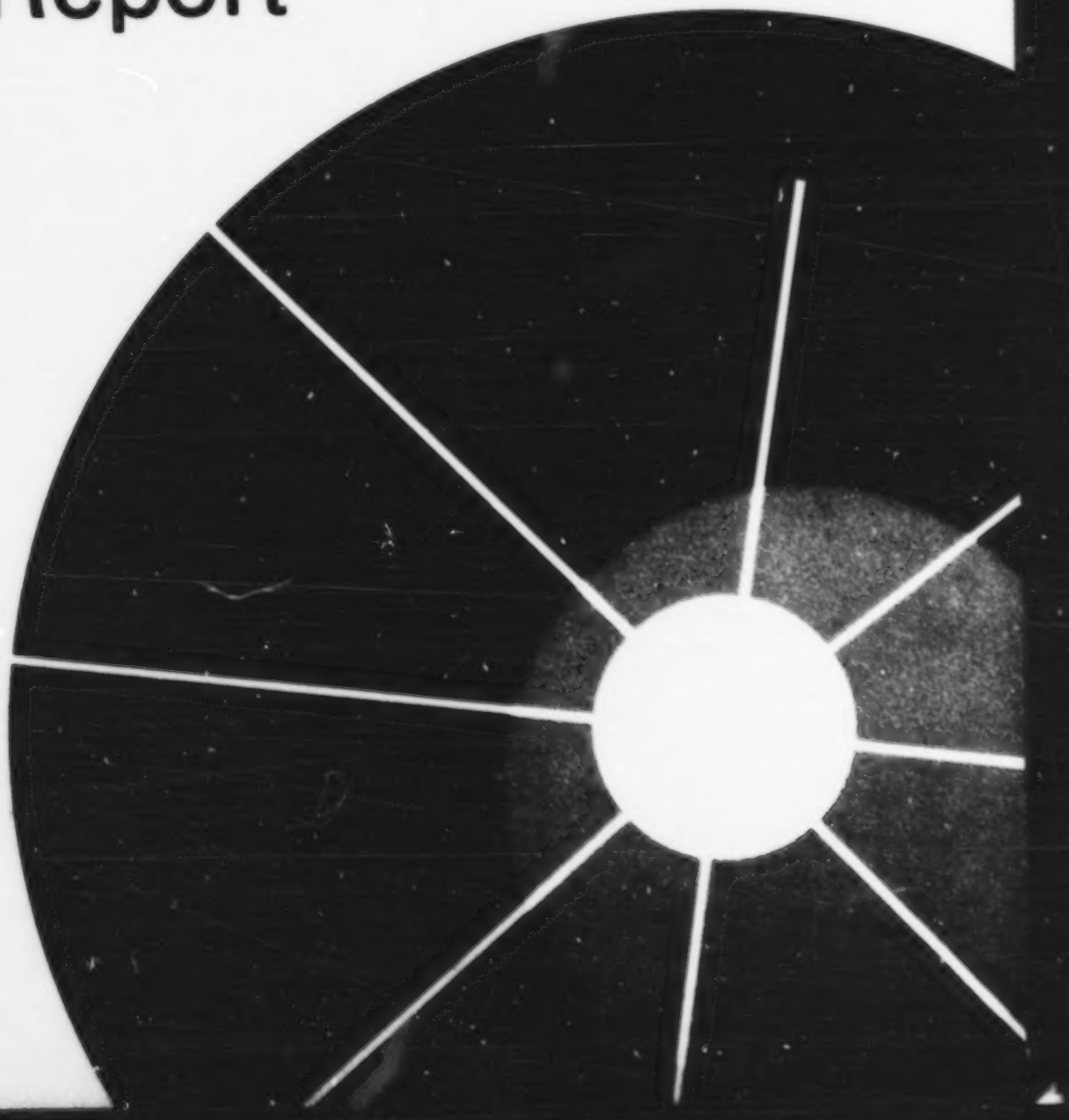
Canada - Saskatchewan Renewables — Conservation Demonstration Program

Final Report



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CANADA-SASKATCHEWAN CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

On March 18, 1980, the governments of Canada and Saskatchewan entered into a Conservation and Renewable Energy Demonstration Agreement. The Agreement, which terminates March 31, 1984, funds the development and demonstration of a wide range of conservation and renewable energy technologies. The program is funded on an equal cost-shared basis by Canada and Saskatchewan, and is administered by Saskatchewan.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies which exploit renewable energy resources, conserve energy, or make its use more efficient;
- To create employment in new or existing industries;
- To develop broad public awareness of the potential of renewable energy and energy conservation technologies.

This report outlines the results of a project funded by the Government of Saskatchewan as represented by Saskatchewan Energy and Mines, and the Government of Canada as represented by Energy, Mines and Resources Canada, under the terms of the Renewables-Conservation Demonstration Program, and contracted with the party identified herein.

However, neither the Government of Saskatchewan as represented by Saskatchewan Energy and Mines, nor the Government of Canada as represented by Energy, Mines and Resources Canada, accept liability for any errors, omissions, or inaccuracies that may be included in or derived from this report, nor do they assume any liability with respect to the use of, or actions resulting from the use of, any information contained in this report.

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Retrofit: Yorkton Agriplex

Retrofit of Recreation Facilities Project — Phase II

Final Technical Report
on a Renewables-Conservation Demonstration Program Project

Conducted By

Saskatchewan Culture and Recreation
and the City of Yorkton

And Supported By

Saskatchewan Energy and Mines
and
Energy Mines and Resources Canada

Project Leader: Cecil Nobes

Miscellaneous
Report FP-36

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* See Overview Report

1. INTRODUCTION

1.1 Scope of Work

In the fall of 1983 Saskmont Engineering Ltd. was commissioned to implement Phase II of a retrofit on the Yorkton Parkland Agriplex.

Phase II follows the Phase I energy audit of the building which culminated in the source report. "Retrofitting of Existing Recreation Facilities Project - Phase I - Yorkton Agriplex by DeLint Huckerby Architects & Engineers dated 30 April 1982".

The recommedations contained in the Phase I audit were analyzed by the City of Yorkton, Saskatchewan Culture & Recreation, Saskatchewan Energy & Mines, and Energy Mines & Resources Canada. Several measures were selected to be implemented for this building.

1.2 Overview of the Agriplex

The Agriplex was built around 1976 and contains nine separate facility areas and totals 87,519 ft^2 in area.

1 - Ice Arena - Regulation size 3,000 spectator arena with concrete floor, artifical ice and underslab heating for full seasons operation. This area is heated with gas fired air handlers. Ice is made approximately 10 months of the year with start-up in August and shutdown in April or May depending upon hockey finals that year.

2 - Dressing Rooms - This area is located under stands on both sides of the ice arena. These areas are heated with electricity. Exhaust fans in each dressing room take air from the arena.

3 - Rampway - This is the main walkway to the ice arena spectator stands and the convention centre. It is heated with electric unit heaters.

4 - Concourse - This area is the main lobby of the building and contains public washrooms and canteens serving the ice arena. This area also houses the administrative offices for the complex. It is heated with a gas fired furnace. The administrative office has a water cooled DX cooling unit. The area is also supplied with direct fired makeup air to match washroom exhaust.

5 - Curling - The curling arena has 8 sheets of ice. It is heated with electric heat. Attached to the curling is a lobby area. The lobby area is heated with a gas fired furnance. Above the lobby is the curling lounge which contains a small canteen and bar. It is also heated with a gas fired furnance.

1. INTRODUCTION - continued

1.2 Overview of the Agriplex - continued

The curling area ice is complete with a concrete slab, artificial ice and underslab heating. Ice is in, October through April, or 6½ months per year.

6 - Pool - The indoor pool is a full sized 25 meter pool with a 3 meter and 1 meter board. In addition there is a whirlpool with access ramp. The pool is heated and ventilated with a direct-fired gas fired makeup air system plus indirect-fired gas fired duct heaters. The systems runs on 100% outside air all year. The pool change rooms are ventilated with a separate direct-fired makeup air system.

Pool filtration is through a diatomaceous filter. This pool is heated with a gas fired boiler. The whirlpool is filtered with a sand filter and heated with an electric boiler.

The pool operates all year, except for a shutdown for cleaning in August.

7 - Convention Centre - This dance hall located on the second floor above the concourse area is complete with a kitchen and bar. The area is heated with gas fired furnances and has rooftop DX units for cooling. As well the area is ventilated with a direct fired makeup air unit which runs 24 hours per day.

8 - Ice Machine - The ice machine room is located off the arena dressing rooms. The plant consists of two - 50 ton ammonia compressors, an evaporative condenser and heat recovery condenser for underslab heating.

The ice plant serves both the curling and hockey arenas using a standard brine system.

9 - Agripavilon - In addition to the area of this complex the agriculture barns north of the complex are serviced with domestic hot and cold water from the Agriplex. The Agriplavilon is not included in this report.

The building has historically used about 86 EKWH/ft^2/YR. of energy (37% electricity, 63% gas) and its demand peaks at about 8.9 watts/ft^2.

1. INTRODUCTION - continued

1.3 Summary of the Source Report

The Phase I report prepared by DeLint Huckerby Architects and Engineers contained the following energy conservation opportunities:

Note: PNCA-1 refers to pool, no cost, architectural item 1.

PNCB-3 refers to pool, no cost, mechanical item 3.

PNCC-2 refers to pool, no cost, electrical item 2.

Likewise A refers to arena, CR refers to curling and CC refers to curling concourse. NC refers to no cost, LC refers to low cost, MC to medium cost, HC to high cost, and NAI to new and innovative items.

1. INTRODUCTION - continued

1.3 Summary of the Source Report - continued

ITEM	DESCRIPTION	COST	SAVING	PAYBACK PERIOD	REMARKS
PNCA-1	Weatherstripping at doors and windows.	N/R	N/R	N/R	Measure a) see also CRNCA-1 & CCNCA-1. Measure b).
PNCA-2	Sealant bead at glue-lam beams.	N/R	N/R	N/R	
PNCA-3	Thermal pool blanket.	$ 3,000	N/R	N/R	
PNCA-4	Upgrade hollow metal door.	$ 300	N/R	N/R	Measure c)
PNCA-5	Paint walls with oil base paint.	N/R	N/R	N/R	
PNCA-6	Add insulation to bond beams.	$ 7,000		4.5 years	
PNCB-1	Showerhead restrictors.	$20 per head	--	70 hours of operation	
PNCB-2	Shut down pool pumps at night.	$ 250	--	70 days	
PNCB-3	Time clock on washroom exhaust and 2 speed motor on makeup air unit.	$ 1,200	$ 1,200	1 year	Measure d)
PNCB-4	Destratification fans.	$ 2,400	--	4 years	Measure 1. See also ANCB-5 and CRNCB-3.
PNCB-5	Area temperature humidity control.	$ 1,500 to $ 2,000	--	1 year	
PNCB-6	Heat domestic water from ice plant waste heater.	$ 2,000	--	260 hours of shower	Measure 7. See also ANAIB-2 and CRNAIB-2.

1. INTRODUCTION - continued

1.3 Summary of the Source Report - continued

ITEM	DESCRIPTION	COST	SAVING	PAYBACK PERIOD	REMARKS
PNCB-7	Change electric whirlpool heater to natural gas.	$ 1,000	--	1333 hours of full load operation.	
PNCB-8	Low leakage dampers on supply air and exhaust air.	$ 6,000	$ 500	12 years	
PNCC-1	Change lighting in pool.	$ 1,125	$ 733	1.6 years	Measure 3
PHCA-1	Re-insulate pool.	$32,200	$ 1,406	22.9 years	
PHCA-1.1	Night set-back air temperature.	N/R	$ 1,530	--	
PHCA-2	Re-insulate roof.	$16,700	$ 1,081	15.0 years	
PHCB-1	Dehumidifier	$80,000	--	7 to 9 years	Measure 2
ANCA-1	Repair arena exit doors.	N/R	N/R	N/R	
ANCA-2	Seal concrete block.	N/R	N/R	N/R	
ANCA-3	Oil base paint external walls of dressing rooms.	$ 4,700	N/R	N/R	
ANCA-4	Access hatches to service filters.	$ 1,500	N/R	N/R	
ANCB-1	Discontinue use of melt pit.	N/R	N/R	N/R	Measure f)
ANCB-2	Turn off entrance way heating.	$ 2,000	--	0.3 years	Measure g)
ANCB-3	Time clock on change room fans.	$ 300	$ 810	0.3 years	Measure 5. See also ANCB-4.

1.3 Summary of the Source Report - continued

ITEM	DESCRIPTION	COST	SAVING	PAYBACK PERIOD	REMARKS
ANCB-4	Night set back change rooms.	$ 500	--	0.7 years	Measure 5. See also ANCB-3.
ANCB-5	Destratification fans.	$ 4,000	N/R	N/R	Measure 1. See also PNCB-4 & CRNCB-3.
ANCB-6	Install low leakage dampers on change room fans.	$ 3,600	$ 972	4.0 years	
ANCC-1	Upgrade lighting in arena general area.	$ 5,100	$ 1,927	2.7 years	Measure 10
ANCC-2	High pressure sodium lights in arena.	$12,000	$ 4,270	2.8 years	
AHCA-1	Exit doors in corridor and insulate underside of bleachers.	$47,200	$48,565	1.0 year	
ANAIB-1	Jet-Ice System	$22,000	--	4.0	Measure 6. See also CRNIAB-1.
	Water Treatment room.	$12,000	--	--	Measure 6. See ANAI and ANAIB-2.
ANAIB-2	Heat reclaim.	$79,000	--	4.0 years	Measure 7. See also CRNAIB-1 and PNCB-6.
CRNCA-1	Weatherstripping at exterior doors.	N/R	N/R	N/R	Measure a). See als PNCA-1 and CCNCA-1.
CRNCA-2	Double glazing viewing windows.	$ 6,300	--	33 years	
CRNCB-1	Night set back curling rink.	$ 300	--	50 hours of operation.	Measure h)

1. INTRODUCTION - continued

1.3 Summary of the Source Report - continued

ITEM	DESCRIPTION	COST	SAVING	PAYBACK PERIOD	REMARKS
CRNCB-2	Space humidity control and and low leakage dampers.	$ 2,500	$ 1,000	2.5 years	Measure i).
CRNCB-3	Destraficiation fans.	$ 3,000	--	4 to 5 years	Measure 1. See also PNCB-4, ANCB-5.
CRLCB-1	Change to gas heating.	$24,000	$ 6,170	4.0 years	
CRLCC-1	Upgrade lighting.	$ 1,400	$ 539	2.6 years	
CRNAIB-1	Jet Ice System	$ 7,000	--	4.0 years	Measure 6. See ANAIB-1.
CRNAIB-2	Heat curling rink with waste heat.	$20,000	--	3.0 years	Measure 7. See alsc ANAIB-2 & PNCB-6.
CCNCA-1	Weatherstripping.	N/R	N/R	N/R	Measure a). See als CRNCA-1 and PNCA-1.
CCNCB-1	Night set back thermostat.	$ 600	N/R	N/R	Measure 8
CCNCB-2	Time clock on washroom and kitchen exhaust fans.	$ 250	--	0.3 years	
CCNCB-3	Air balance MU-1	$ 5,000	--	2.0 years	Measure 9
CCLCA-1	Insulate block walls.	$14,000	$ 425	32.9 years	
CCLCC-1.1	Upgrade lighting.	$ 1,890	$ 1,329	1.4 years	
CCLCC-1.2	Delete fixtures in lobby.	nil	$ 456	immediate	
CCLCC-1.3	Convert lamps to energy saving type.	N/R	N/R	N/R	

1. INTRODUCTION - continued

1.4 Measures Chosen For Retrofit

The measures chosen for the Phase II retrofit differ with the Source Report as follows:

Item	Measure	Source Report
Replace Incandescent Fixtures	3	PNCC-1
- capital costs	$ 1,800	$ 1,125
- savings	$ 450	$ 723
- There have been no reasons given for the differences.		
Time Clock for Pool	4	PNCB-3
- capital costs	$ 300	$ 1,200
- savings	--	$ 1,200
- Difference is due to deletion of 2-speed motor.		
Time Clock and Night Setback in arena.	5	ANCB-3 & ANCB-4
- capital costs	$ 500	$ 800
- savings	--	$ 810
- There have been no reasons given for the differences.		
Jet Ice	6	ANAIB-1 & CRNAIB-1
- capital costs	$42,000	$35,000
- There have been no reason given for the differences.		
Air Balance	9	CCNCB-3
- savings	$ 1,250	$ 2,500
- There have been no reasons given for the differences.		
Lighting Modifications	10	ANCC-1
- capital costs	$ 5,000	$ 5,100
- savings	$ 1,250	$ 1,927
- There have been no reasons given for the differences.		
Caulking Arena Exhaust Fan		
- Measure e) was not noted in the source report.		

1. INTRODUCTION - continued

1.4 Measures Chosen For Retrofit - continued

Agreements with the City of Yorkton were prepared. Several measures were to be implemented by the City without consultants. The following measures were to be implemented through Saskmont Engineering.

Measure	Description	Cost	Annual Saving	Payback Period
1	Install destratification fans in pool, arena and curling rink.	$ 9,400	$ 1,950	4.8 years
2	Install electric dehumidifier on pool ventilation system to reduce fresh air requirements.	$80,000	$10,000	8.0 years
3.	Replace incandescent fixtures with fluorescent in pool area and arena gallery.	$ 1,800	$ 450	4.0 years
4.	Install time clock to shut down change room exhaust fans during unoccupied periods.	$ 300	--	--
5.	Install time clock and night set back thermostat to set-back temperature in arena change rooms during unoccupied periods.	$ 500	--	--
6.	Install "jet-ice" de-ionized water treatment for water used for flooding arena and curling rink.	$42,000	$ 8,750	4.8 years
7.	Install heat recovery equipment to reclaim chiller waste heat to heat DHW, pool, curling rink, change room arena.	$105,000	$ 20,500	5.1 years
8.	Replace existing thermostats with night set back thermostats in convention/concourse area.	$ 600	--	--

1. INTRODUCTION - continued

1.4 Measures Chosen For Retrofit - continued

Measure	Description	Cost	Annual Saving	Payback Period
9.	Air balance all HVAC systems.	$ 5,000	$ 1,250	4.0 years
10.	Lighting modification for improved efficiency.	$ 5,000	$ 1,250	4.0 years
	TOTALS	$249,600	$ 44,150	5.7 years

The owner's retrofit was to consist of the following measures:

a) Weatherstripping on exterior doors.

b) Seal laminated beam/wall joints in pool area.

c) Replace hollow metal door with insulated door on pool equipment room.

d) Install time clock to shut down pool washroom exhaust fans were unoccupied.

e) Caulk around exhaust fan housings in arena.

f) Discontinue use of ice melt pit.

g) Discontinue use of arena entrance way heaters.

h) Install time clock to control curling temperatures to 30°F when occupied.

i) Install humidistat to control curling rink exhaust fans.

1.5 Measures Implemented

The City prepared design and tender documents on measures 1, 3, 4, 5, and 10 themselves, having the work done in the summer of 1983.

Measures 2, 6, 7, and 9 were prepared by Saskmont in the fall of 1983. (See Appendix IV).

Measure 8 was not tendered as alternate operating procedures were recommended in place of a time clock.

Measure 2 and measure 6 were not constructed as the capital costs of all measures exceeded the allowable budget. Section 4 of this report summarizes the work that was done.

2. TECHNICAL ANALYSIS

2.0 Methodology

The energy calculations done in this section of the report are done on the basis of the calculation methodology contained in Appendix II. Reference is made to this Appendix by stating "Calculation C-3" or merely "C-3".

Assumptions made are generally based upon the source report, and a review of the plans, specifications and building.

All calculations have been done in detail to explain the assumptions used, however this detail does not improve the accuracy. In most cases the accuracy is at best ±20%.

Utility costs used in this report are as follows:

Gas consumption	13.94¢/m^3
Electrical consumption	2.72¢/kWhr.
Electrical demand	$9.72/KVA

These costs differ from other utility costs in the accompanying reports. See Appendix II for further information on utility costs.

2. TECHNICAL ANALYSIS - continued

2.1 Measure 1 - Install Destratification Fans.

Situation - The pool, curling and ice arenas are high ceiling buildings.

In these high ceiling rooms hot air tends to rise to the ceiling. This stratification wastes energy as ceiling temperatures are higher than needed.

Solution - The source report recommended installing ceiling destratification fans in each of the above areas:

Pool	- 6 fans recommended.
Arena	- 8 fans c/w reversible direction motors recommended.
Curling	- 6 fans c/w reversible direction motors recommended.

The fans in the pool are to be located and adjusted in speed so that they do not blow across the pool surface.

The fans in the curling and arena area are to blow upwards when ice is in so that they do not increase loads on the ice plant.

The work consisted of 8 fans in the arena and 6 fans in the pool. In the curling area the City installed 12 fans instead of 6 recommended. In addition the City installed an additional 10 fans in the clurling lounge areas.

The tender for the fans was prepared by the City. See Appendix IV.

Energy Calculations

Pool using calculation C-6.

Roof area = 9016 ft^2
R-value = 11.97, U-value 0.084
Wall area (top 5') = 1523 SF
R-value = 6.95, U-value 0.14

$\frac{BTUH}{°F}$ = 9016 x .084 + 1523 x .14

= 971

Heating season - 35 weeks, 168 hours per week

Stratified temperature assume 20°F

C-6: $\frac{971 \times 35 \times 168 \times 20 \times 0.8}{35313 \times 0.7} = 3694\ m^3$

Thus total energy saving for the pool are 3694 m^3 at 14.6¢ = $539 per year.

When the pool dehumidifier is implemented, the above savings will drop by about 50% to 1847m^3 or $255 per year.

2. TECHNICAL ANALYSIS - continued

2.1 - continued

Energy Calculations - continued

Arena using calculation C-6 for ice arenas.

Ai = 17000 ft^2
e = 0.90
HRS = 6192
Tr = 45°F
Ti = 22°F
Rr = 7.7
Fr = 37000 ft^2
CD = 0.8

Thus with no ceiling fans Ts = 20, To = -5, Vi = 25, Vr = 0

$$\text{Ice Plant} = \frac{(0.1713)\ (17000)\ (0.90)\ (6192)}{12000}\left[\left(\frac{45 + 20 + 459.67}{100}\right)^4 - \left(\frac{22 + 459.67}{100}\right)^4\right]$$

$$+ \frac{(25)}{462}\ (17000)\ (45 - 5 - 22)\ \frac{(6192)}{(12000)}$$

$$= 296858 + 8544$$

$$= 305412 \text{ kWhrs.}$$

$$\text{Heating} = \left(\frac{1}{.92 - \frac{0}{985} + 7.7}\right)\frac{37000 \times 10526 \times 24}{35313 \times 0.70}$$

$$+ \frac{(25)\ (17000)\ (45 - 5 - 22) \times 6192}{(462)\ (35313)\ (0.70)}$$

$$+ \frac{(0.1713)\ (17000)\ (0.90)\ (6192)}{(35313)\ (0.70)}\left[\left(\frac{45 + 20 + 459.67}{100}\right) - \left(\frac{22 + 459.67}{100}\right)^4\right]$$

$$= 43867 + 4148 + 144111$$

$$= 192126 m^3$$

With ceiling fans blowing up Ts = 5, To = 5, Vi = 25, Vr = 200

$$\text{Ice Plant} = \frac{(0.1713)\ (17000)\ (0.90)\ (6192)}{12000}\left[\left(\frac{45 + 5 + 459.67}{100}\right)^4 - \left(\frac{22 + 459.67}{100}\right)^4\right]$$

2. TECHNICAL ANALYSIS - continued

2.1 - continued

Energy Calculations - continued

$$+ \frac{(25)\ (17000)\ (45 - 5 - 22)\ (6192)}{(462)\qquad\qquad\qquad

2. TECHNICAL ANALYSIS - continued

2.1 - continued

Energy Calculations - continued

Curling using calculation C-6 - continued

$$+ \frac{(25)\ (10700)\ (35 - 5 - 28)\ (3696)}{(462)\qquad (12000)}$$

$$= 69123 + 357$$

$$= 69480 \text{ kWhrs}$$

$$\text{Heating} = \frac{(\qquad 1 \qquad)}{(.92 - \frac{0}{985} + 625)} \frac{(19540)\ (7742)\ (24)}{3410}$$

$$+ \frac{(25\ )}{(462)} \frac{(10700)\ (35 - 5 - 28)\ (3696)}{3410}$$

$$+ \frac{0.1713\ (10700)\ (0.90)\ (3696)}{(3410)} \left[\frac{(35 + 20 + 459.67)^4}{(\qquad 100 \qquad)} \right.$$

$$\left. - \frac{(28 + 459.6)^4}{(\quad 100 \quad)} \right]$$

$$= 148496 + 1256 + 243248$$
$$= 393000 \text{ kWhrs.}$$

With the ceiling fans blowing upwards Ts=5, To=-5, Vi=25, Vr=200.

$$\text{Ice Plant} = \frac{0.1713\ (10700)\ (0.90)\ (3696)}{12000} \left[\frac{(35 + 5 + 459.67)^4}{(\qquad 100 \qquad)} \right.$$

$$\left. - \frac{(28 + 495.67)^4}{(\quad 100 \quad)} \right]$$

$$+ \frac{25\ (10700)\ (35 - 5 - 28)\ (3696)}{(462)\ (12000)}$$

$$= 29346 + 357$$
$$= 29703 \text{ kWhrs.}$$

$$\text{Heating} = \frac{(\qquad 1 \qquad)}{(.92 - \frac{200}{985} + 6.25)} \frac{(19540)\ (4752)\ (24)}{3410}$$

$$+ \frac{(25\ )}{(462)} \frac{(10700)\ (35 - 5 - 28)\ (3696)}{(3410)}$$

$$+ \frac{0.1713\ (10700)\ (0.90)\ (3696)}{3410} \left[\frac{(35 + 5 + 459.67)^4}{(\qquad 100 \qquad)} \right.$$

$$\left. - \frac{(28 + 59.67)^4}{(\quad 100 \quad)} \right]$$

2. TECHNICAL ANALYSIS - continued

2.1 - continued

Energy Calculations - continued

Heating - continued

= 93803 + 1256 + 103270
= 198329 kWhrs.

Thus savings in the ceiling are:

Electricity - Ice Plant -	69480 - 29703 =	39777 kWhrs
Electricity - Heating -	39300 - 198329 =	194671 kWhrs
		234448 kWhrs

For an annual saving of $6377

If the curling rink is converted to gas heat, the savings are as follows:

Electricity Ice Plant -	39777 kWhrs	- $1082
Gas Heating -	26855m^3	- 3744
		$4825 per year

And if Measure 7, the heat recovery system is installed, the gas savings are cut in half to 13427m^3 for an annual saving of $2953.

Summary

The tender prices received for the fans was approximately $12,675.25 and work was completed late in the summer of 1983.

The economics is then as follows:

	Cost	Without Heat Recovery Savings	Payback	With Heat Recovery Savings	Payback
Pool 6 fans	$ 1,636	$ 514	3.2 yrs.	$ 514	3.2 yrs.
Arena 8 fans	4,000	12,584	0.3 yrs.	7,819	0.5 yrs.
Curling 22 fans	6,673	6,377	1.0 yrs.	2,953	2.3 yrs.
Total	$12,309	$19,475	0.7 yrs.	$11,286	1.1 yrs.

2. TECHNICAL ANALYSIS - continued

2.2 Measure 2 - Electric Dehumidifier in Pool

Situation - The indoor pool is ventilated with an 18000 CFM direct fired makeup air unit which operates on 100% outside air 8760 hours of the year. The pool air is then heated with duct furnaces.

The main pool is heated with a gas fired boiler. The whirlpool is heated with an electric boiler.

The energy use of the pool system is estimated to be 345 EKWH/ft^2/year.

Solution - The Source Report recommended the installation of a dehumidifier to eliminate the large amounts of outside air and recover the heat to the pool waters and air.

Tender documents were prepared on this item. (See Appendix IV - Drawing ME-4).

Energy Calculations

Review of energy used in pool

a) Cost of heating makeup air.

C-3: $\frac{18000 \times 1.1 \times 11640 \times 24 \times 0.8}{35313 \times 1.0} = 125310 m^3$ of gas

b) Cost of heating main pool using equations from C-9.

A = 3444 ft^2
Ta = 80°F, 60% relative humidity
Tp = 85°F
V = 20 fpm

then W = 210 pounds/hour

and assuming

Occupied Hours = 8 hours, Unoccupied Hours = 16

Tm = 45°F
AW = 3444 + 1488 = 4932 ft^2
UW = 0.10
TG = 40°F

2. TECHNICAL ANALYSIS - continued

2.2 - continued

b) - continued

Then Energy use due to evaporation = 2452.8 million BTU's 83%

Energy use due to makeup = 98.1 million BTU's 3%

Energy use due to heat loss to air = 226.3 million BTU's 8%

Energy use due to heat loss to ground = 194.4 million BTU's 7%

Total = 2971.6 million BTU's 100%

and total energy use of boiler is

$\frac{2971600000}{35313 \times .7}$ = 120215m^3 per year

c) Cost of heating whirlpool

A = 160 SF
Ta = 80°F, 60% relative humidity
Tp = 105°F
V = 20 fpm

then W = 27 lbs/hour

and assuming:

Occupied Hours = 8, Unoccupied Hours = 16
TM = 45°F
AW = 256 SF
UW = 0.10
TG = 40°F

Then Energy use due to evaporation = 315.4 million BTU's 79%
Energy use due to makeup water = 18.9 million BTU's 5%
Energy use due to heat loss air = 52.6 million BTU's 13%
Energy use due to heat loss to ground = 14.6 million BTU's 4%

Total 401.5 million BTU's 100%

Thus total energy by the whirlpool boiler is

$\frac{401500000}{3410}$ = 117742 kWhrs per year

2. **TECHNICAL ANALYSIS** - continued

2.2 - continued

d) Cost to heat the building using calculation C-4.

Roof area: 9016 ft^2 U value = 0.084
Wall area: 7330 ft^2 U value = 0.143
Infiltration: 1/4 AC/hour 216336 CF = 900 CFM

Therefore UA = 9016 x 0.084 + 7330 x 0.143 = 900 x 1.1
= 2795

C-4: $\frac{2795 \times 11640 \times 24 \times 0.8}{35313 \times 0.7} = 25264 m^3$

However there is an energy transfer between the pools and air amounting to 226.3 + 52.6 = 278.9 million BTU's/year. This will reduce the winter heating requirement. Therefore calculation C-4 is modified as follows:

C-4: $\frac{2795 \times 11640 \times 24 \times 0.8 - 0.5 \times (278.9 \times 10000000)}{35313 \times 0.7}$

= $19629 m^3$ of gas annually for heat.

e) Electrical energy use using calculation C-1.

Electrical energy use consists of

- lights - 10.5 kw x 10 hours per day x 365 days = 38325
- pool pump - 7.5 HP x 1 x .8 x 8760 = 52560
- whirlpool pump - 5 HP x 1 x .8 x 8760 = 35040
- fans - [11 kw + 3 (2.2 kw)] = 17.6 x .8 x 8760 = 123340

249265 kWhrs per yr.

Thus the total energy use of the pool (not including lockers) is:

		gas (m^3)	elec (kWhrs)	EKWH
a)	Makeup air -	125310		1267
b)	Main pool heater	120215		1245
c)	Whirlpool heater		117742	118
d)	Heat building	19629		139
e)	General electricity		249265	249
	Total	265154	367007	3018

Therefore the pool has an energy index of about 3113000 EKWH 9016 ft^2 = 345 EKWH/ft^2/yr.

2. TECHNICAL ANALYSIS - continued

2.2 - continued

e) - continued

Affect of Pool Blankets

Pool blankets reduce the evaporation rate of the pool and reduces the heat transfer between the pool and the air. Thus changing nothing else pool blankets will save energy as follows:

Main pool (note unoccupied hours = 4)			
Energy use due to evaporation	=	1533.0 million BTU's	78%
Energy use due to makeup water	=	61.3 million BTU's	3%
Energy loss to air	=	173.5 million BTU's	9%
Energy loss to ground	=	194.4 million BTU's	10%
Total		1962.2 million BTU's	100%

The pool boiler's energy use is reduced to 79380m^3/hour.

Whirlpool

Energy use due to evaporation	=	197.1 million BTU's	75%
Energy use due to makeup water	=	11.8 million BTU's	4%
Energy loss to air	=	40.3 million BTU's	15%
Energy loss to ground	=	14.6 million BTU's	6%
Total		263.8 million BTU's	100%

The whirlpool boiler's energy use is reduced to 77361 kWhrs.

Makeup air with the present system would be unchanged.

Building heating would increase slightly as there is less heat coming from the pool.

$$\frac{2795 \times 11640 \times 24 \times 0.8 - 0.5 \times (40.3 + 173.5) \times 1000000}{35313 \times 0.7} = 20945 m^3 \text{ gas for both}$$

Therefore the net affect of pool blankets is:

	Energy Saved from Boilers (Million BTU's)	Increase in Room Heating	gas Net Savings (Increase) Gas (m^3)	elecrical Net Savings (Increase) Elec. (kWh)	Total (EMWH)
Whirlpool	137.7	6.1	(247)	40381	37.8
Pool	1009.4	26.4	39767	-	411.8
Total	1147.1	32.5	39520	40381	449.6 EMWH

And the savings are:

Whirlpool blanket $1064/year
Pool blanket $5544/year

2. TECHNICAL ANALYSIS - continued

2.2 - continued

e) - continued

Dehumidifier

a) Installation of the proposed dehumidifier will delete entirely the energy cost of the makeup air except for leakage through the outside air damper assumed at 5%. Thus total savings are 95% of previous energy use:

	W/O Pool Blanket	With Pool Blanket
Saving	119045m^3	119045m^3

The 5% leakage can be heated with recovered heat resulting in a additional saving of 6266m^3 of natural gas.

b) The dehumidifier will operate only during the winter season (until it begins to overheat the building). The dehumidifier will recover heat to the main pool heater.

Assuming that the dehumidifer operates for an 8 month season maximum saving in the main pool heater are 2/3 of the original

	W/O Pool Blanket	With Pool Blanket
Maximum Saving	80143m^3	52920m^3

c) Likewise for the Whirlpool

	W/O Pool Blanket	With Pool Blanket
Maximum Savings	78495 kWhrs.	51574 kWhrs.

d) The recovered heat for the dehumidifier will recover heat to heat the pool air. Thus maximum savings are equivalent to the original energy cost. Actual maximum savings will be less as peak loads will not match. (Assume 75%).

	W/O Pool Blanket	With Pool Blanket
Maximum Savings	19629m^3	20945m^3
Actual Savings	14722m^3	15709m^3

e) General electrical requirements in the pool are not changed.

2. TECHNICAL ANALYSIS - continued

2.2 - continued

e) - continued

Dehumidifier - continued

f) To recover the above heat an electrical compressor is used to remove water from the air (brackets indicates with pool cover).

Total evaporation from the pool is 2452.8 x million BTU/1000 = 2452800 lbs/year (1533000 lbs/year).

Total evaporation from the whirlpool is 315.4 x million BTU/1000 = 315000 lbs/year (197100 lbs/year).

Total evaporation 2,767,800 lbs (1730100 lbs) of water per year.

2/3 of the evaporation occurs in winter when the dehumidifier is operating or 1,845,200 lbs/year (1153400 lbs/year)

Assuming a constant 80°F air temperature and 60% relative humidity and 12000 CFM of supply air the humidity rate of the return air from the pool is 92 grain/lb of dry air, with an enthalpy of 34 BTU/lb.

To remove 1845200 lbs (1153400 lbs) of moisture the average dehumidifier rate must be 316 lbs/hour (198 lbs/hour) which implies that the supply air's specific humidity must be reduced to 51 grain/lb of dry (66 grain/lb) which requires a supply air temperature after the dehumidification coil of about 52°F (58°F) and an enthalpy of 20 BTU/lb. (24 BTU/lb) the average cooling requirement is:

4.5 x 12000 CFM x (34-20)/12000 = 63 TONS without a pool cover and

4.5 x 12000 x (34-24)/12000 = 45 TONS with a pool blanket.

Energy cost is therefore (using calculation C-8)

Without pool blanket 63 TONS x 5840 hours x 1 kW/TON.H x 100% = 367920 kWhr
With pool blanket 45 x 5840 x 1 x 100% = 262800 kWhr

2. TECHNICAL ANALYSIS - continued

2.2 - continued

e) - continued

Dehumidifier - continued

Total heat recovery is

With pool blanket 63 TONS x 5480 hour x 12000 BTU/TON + 367920 kwhrs x 3410 $\frac{BTU}{kWhr}$

= 5669.7 million BTU's

Without pool blanket 45 x 5480 x 12000 + 262800 x 3410 = 4049.7 million BTU's

Reheat required to heat the air stream back to 80°F is:

Without pool blanket 1.1 x 12000 x (80 - 52) x 5760 hour = 2128.9 million BTU's.

With pool blanket 1.1 x 12000 x (80 - 58) x 5760 hour = 1672.7 million BTU's.

Thus the net heat available for heat recovery is:

Without pool blanket = (5669.7 - 2128.9) = 3540.8 million BTU's

With pool blanket = (4049.7 - 1672.7) = 2377 million BTU's

Now the maximum energy estimated to be saved in items b), c) and d) were

	w/o pool blanket (million BTU)	with pool blanket (million BTU)
a) damper leakage	221.3	221.3
b) pool heater	1981.1	1308.1
c) whirlpool	267.7	175.9
d) heating	363.9	388.3
Total heat used:	2834.0	2093.6
Recovered heat available:	3540.8	2377.0

2. TECHNICAL ANALYSIS - continued

2.2 - continued

e) - continued

Dehumidifier - continued

f) - continued

Thus since total recovered heat is greater than the total heat used the pool will overheat thus the dehumidifier will not run all the time. It will operate with only enough to balance the recovered heat.

W/O Pool Blanket	With Pool Blanket
80%	88%

Therefore energy use by the dehumidifier will be:

	W/O Pool Blanket	With Pool Blanket
Electrical Consumption	294336 kWhrs	231264 kWhrs
Electrical Demand (40 kw)	320 KVA per year	320 KVA per year

And savings (increase) are as follows:

		W/O Pool Blanket	With Pool Blanket
Gas Consumption (m^3)	a)	119045m^3	119045m^3
	a) recovered	6266m^3	6266m^3
	b)	80143m^3	52920m^3
	c)	-	-
	d)	14722m^3	15709m^3
	e)	-	-
	f)	-	-
Total savings in gas		220176m^3	193940m^3
Electrical Consumption	a)	-	-
	b)	-	-
	c)	78495 kWhrs	51574 kWhrs
	d)	-	-
	f)	(294336) kWhrs	(231264) kWhrs
Total savings		(215841) kWhrs	(179630) increase
Electrical demand		(320) KVA	(320) KVA increase

2. TECHNICAL ANALYSIS - continued

2.2 - continued

e) - continued

Dehumidifier - continued

f) - continued

Thus annual savings for the dehumidifier are:

	Without Pool Blanket	With Pool Blanket
Gas	$30,693	$27,035
Electrical consumption	(5,871)	(6,290)
Electrical demand	(3,110)	(3,110)
Total savings	$21,712	$17,635

In terms of the pool's energy index

Existing pool	345 EKWH/ft^2/yr
With pool blankets only	295 EKWH/ft^2/yr
Without pool blankets and with dehumidifier	116 EKWH/ft^2/yr
With pool blanket and with dehumidifier	92 EKWH/ft^2/yr

2. TECHNICAL ANALYSIS - continued

2.3 Measure 3 - Fluorescent Fixtures In Pool

Situation - The lighting in the pool area consisted of a mix of fluorescent, mercury vapour, and a large proportion of incandescent pot lights.

The pool area is under lit and the change rooms and lounge were overlit.

Solution - The source report recommended:

.1 Replacing the 400 watt mercury fixtures in the pool with 400 watt high pressure sodium to increase lighting level.

.2 Reduce lighting in change rooms by delamping.

.3 Change shower room fixtures to vapour proof fluorescent.

.4 Replace pool lounge incandescent fixtures with fluorescent. These fixtures were already fluorescent fixtures.

Costs and savings in the source report were based upon changing 29 incandescent fixtures to 15 fluorescent fixtures.

The above work was done directly by the owner. The final solution consisted of changing the pot lights in the change room to fluorescent lights.

Thus 5-100 watt fluorescent lights replaced the 12-150 watt incandescent fixtures.

Energy Calculation

Total savings are 1300 watts. Assuming 4380 hours of operation total savings are:

1.3 KVA x 12 demand at $9.72/KVA	=	$152
5694 kWhrs at 2.72¢/kWhr	=	155
Total		$307/year

2. TECHNICAL ANALYSIS - continued

2.4 Measure 4 - Time Clock For Arena Change Room Exhaust Fans

Situation - The exhaust fans in the arena change rooms are operated manually. These fans are not always switched off at night.

These fans need only operate during occupied hours having a normal run time of about 12 hours per day 7 days per week (84 hours per week, 11 months per year) or 4004 hours per year.

Solution - The source report recommended installation of a time clock to automatically shut the fans off. This work was tendered directly by the owner, the time clock was installed and the fans were set to operate from 4:00 p.m. to midnight only or 2667 hours per year.

Energy Calculation - The exhaust fans of concern are as follows:

	Room #	Description	Air Volume (CFM)	Motor Size (HP)
FE - 4	A115	Dressing Room	250	1/12
- 5	A110	Dressing Room	250	1/12
- 6	A108	Men's Washroom	350	1/25
- 7	A107	Ladies' Washroom	350	1/25
- 8	A144	Dressing Room	250	1/12
- 9	A139	Dressing Room	250	1/12
-10	A138	Officials	150	1/25
-11	A134/137	Dressing Room	250	1/12
FE -12	A130/133	Figure Skating	120	1/25
	Total		2220 CFM	0.58 HP

Thus total electrical savings due to reduced fan operation are calculated using calculations C-1

C-1: 0.58 HP x 1 x 80% x 2667 x 10% = 124 kWhrs.

Energy savings due to reduced heating of makeup air occurs in 2 separate stages. Stage 1 is infiltration to the arena. This air is heated to about 40°F by the arena gas fired heater. Energy from this is calculated using calculation C-2 on a month by month basis.

2. TECHNICAL ANALYSIS - continued

2.4 Measure 4 - Time Clock For Arena Change Room Exhaust Fans - continued

Energy Calculation - continued

	Average Temperature	Energy Use (m^3)
Oct.	40°F	0
Nov.	20°F	47 *m^3
Dec.	4°F	88
Jan.	-6°F	113
Feb.	2°F	84
Mar.	14°F	64
Apr.	37°F	7
May	51°F	0
Total		403m^3 of natural gas

*C-2: $\frac{2220 \times 1.1 \times (40-20) \times 1 \times 10\% \times (30 \times 8)}{35313 \times .7} = 47m^3$

Energy savings due to reduced electrical heating in change rooms using calculation C-2 and assuming makeup air temperatures are at 40°F all year round due to the ice plant:

C-2: $\frac{2220 \times 1.1 \times (70 - 40) \times 1 \times 10\% \times 2667}{3410} = 5703$ kWhrs

Therefore total energy saved by this measure assuming no heat recovery system is

Gas:	403m^3 at 13.94¢ =	$ 56
Electricity:	124 + 5730 = 5854 kWhrs at 2.72¢ =	$159
		$215/year

If the heat recovery system is added 50% of the savings due to heating will be lost as this will be done by recovered heat and energy saving will be reduced to:

Gas:	201m^3 at 13.94¢ =	$ 28
Electricity:	2927 kWhrs at 2.72¢ =	$ 80
		$108/year

The source report estimated a savings of $810 per year based on this measure. Their estimate differs as they assumed 2700 CFM of exhaust and assumed that all heating would be done by electricity with electricity costs at 4.3¢/kWhr.

2. TECHNICAL ANALYSIS - continued

2.4 Measure 4 - Time Clock For Arena Change Room Exhaust Fans - continued

Energy Calculation - continued

Thus their simplified calculation seems to be based upon calculation C-3 as follows:

$$\frac{1.1 \times 11362 \times 24 \times 0.8}{3410} = 70.4 \text{ kWhrs/year}$$

per CFM of air at 4.3¢/kWhr is $3/CFM/year

Note: The use of 4.3¢/kWhr is a good average electrical rate for all facilities in the province.

2. TECHNICAL ANALYSIS - continued

2.5 Measure 5 - Time Clock and Set Back for Arena Change Rooms

Situation - The arena change rooms are electrically heated. The amount of heat is controlled by self contained thermostats on these electric heaters.

The unit mounted thermostats are located at the floor and are not calibrated. The thermostats are not likely set to maintain a correct temperature.

The heating in the arena is not set back in temperature at night.

Solution: The source report recommended installation of a time clock and a night set back thermostat to set back temperatures to 40°F at night.

The owner tendered this work himself and in addition to providing night set back the owner provided a system of duty cycling to reduce demand costs.

This involved the use of timer to only allow heating in 1/2 of the dressing rooms at a time. First the east dressing room is heated for 15 minutes, while the west dressing room is unheated, then the west dressing room is heated for 15 minutes while the east dressing room is shut off.

The above duty cycle can be done in all but the coldest temperatures.

Night set back was not done as there is insufficient additional heating capacity to properly warm-up the dressing rooms.

Energy Calculation

Heat loss calculations for the arena dressing rooms were done and are tabulated in Table 2.1.

2. TECHNICAL ANALYSIS - continued

TABLE 2.1 - DRESSING ROOM HEAT LOSSES

Room	Descrip	Exterior Heat (1) Loss (Watt)	Interior Heat (2) Loss (Watt)	Ventilated Heat Loss (Watt)	Total Heat Loss Loss (Watt)	Installed Capacity Wat
A105	Workshop	3810	5690	2420	11920	9000
A106	Staff Room	2840	2820	2420	8080	9000
A107	W. Washroom	3610	2380	3390	9380	8000
A108	M. Washroom	3420	2880	3390	9690	8000
A110	Dressing Room	4250	4910	2420	11580	12000
A115	Dressing Room	4250	4220	2420	10890	12000
A116	Equipment Room	3050	3720	-	6770	9000
A130	Figure Skating	2750	2080	580	5410	7000
A1333	Figure Skating	2100	2730	580	5410	6000
A134	Dressing Room	2420	2400	1210	6030	7500
A135	Washroom	1400	1390	-	2790	4000
A137	Dressing Room	3050	3720	1210	7980	9000
A138	Officials	1380	2060	1450	4890	4500
A139	Dressing Room	4230	4190	2420	10840	12000
A144	Dressing Room	5730	5690	2420	13840	16500
Total		48290	50880	26330	125500	133500

(1) At 70°F indoor -40° outdoor U-wall = 0.24, edge loss = 70 BTUH/ft
(2) At 40°F arena temp., U-partition = 0.5

2. TECHNICAL ANALYSIS - continued

2.5 Measure 5 - Time Clock Set Back for Arena Change Room - continued

The total heat loss and installed capacity do not provide a large warm-up factor if the exhaust fans are running at the same time, therefore warm-up will have to occur with the exhaust fans off.

Room A116 is an equipment room and should always have its thermostat set at less than 70°F.

Assuming an 8 hour set back period (allowing 4 hours for warm-up when exhaust fans are off) set back period is 56 hours per week and energy savings are as follows:

$\frac{\text{BTUH}}{°\text{F}}$ for exterior loads in = 48290 watts x 3.410/110
= 1497 BTUH/°F

C-6: for exterior load = $\frac{1497 \times 35 \times 56 \times 20 \times 0.8}{3410}$

= 13767 kWhrs per year

Due to the ice plant the interior portion of the heating load is not related to exterior temperatures and thus the heating season is extended to 10 months or 43 weeks per year.

Interior load savings are thus

$\frac{\text{BTUH}}{°\text{F}}$ = 50880 x 3.41/30
= 5783

C-6: for interior load = $\frac{5783 \times 43 \times 56 \times 20 \times 0.8}{3410}$

= 65339 kWhrs

Thus total savings by implementing this night set back measure are 79106 kWhrs at 2.72¢ = $2151 per year.

For duty cycling if 1/2 of the heating load can be turned on at one time. Demand saving are 133500/2/1000 = 67 KVA per month.

This on a 10 month season amounts to 670 KVA per year, however experience has shown that duty cycling cannot be maintained at very cold temperatures. Therefore assuming no duty cycling in December, January, February and March then the total saving is about 402 KVA per year at 9.72/KVA, or $3893/year.

Total savings then are $6044/year.

2. TECHNICAL ANALYSIS - continued

2.5 Measure 5 - Time Clock Set Back for Arena Change Room - continued

Installation of the heat recovery system reduces the payback of the system, as up to 50% of the required heat will be provided by heat recovery, more in the summertime.

Thus with heat recovery, savings due to interior heat recovery drop to 1/4 of those stated or 16335 kWhrs for a total saving of 30120 kWhrs for a total saving of $4712 per year.

The source report estimated energy saving for night set back to be about $350/year, rather than the $819 noted above. In addition the source report did not include a demand saving by duty cycling which accounts for $3893 of the estimated saving.

Actual total savings from this element are $3893 as the night set-back feature was not implemented, only the duty cycling.

2. TECHNICAL ANALYSIS - continued

2.6 Measure 6 - "Jet-Ice" System for Ice

Situation - The ice plant and heated waters for flooding are estimated to account for 11% of the Agriplex's total energy use.

Solution - In order to reduce the energy used by the ice plant the source report recommended installation of a Jet-Ice demineralized water system.

This measure was not installed under this program in order to maintain total cost within the allowable budget. However the owner is intending to install the system in the near future.

Energy Calculations

Energy Used By Current Ice Plant

The existing ice plant consists of 2 x 75HP ammonia compressors operating an average of 4113 full load loss per year (see Technical Analysis of measure 7 for the ice plants assumed operation).

a) Thus the energy to operate the ice plant compressors is:

C-1: (2 x 75HP) x 1 x 80% x 3648 x 100% = 437760 kWhrs.

b) Energy used by the brine pumps using calculation C-1 are as follows:

	HP	HOURS/YEAR	kWhr/YR
Ice Arena Brine Pump	20 x .8	x 49 wks x 168	131712
Ice Arena Underfloor Heating Pump	5 x .8	x 49 wks x 168	32928
Curling Arena Brine Pump	15 x .8	x 40 wks x 168	80640
Curling Arena Underflow Heating Pump	5 x .8	x 40 wks x 168	26880
Main Circulation Pump	25 x .8	x 49 wks x 168	164640
Total			436800 kWhrs.

c) Energy use by the condenser fan and pump

Condenser Fan 15HP x .8 x 3648 = 43775 kWhrs.
Condenser Pump 3HP x .8 x 3648 = 8755 kWhrs.

Total 52530 kWhrs.

2. TECHNICAL ANALYSIS - continued

2.6 Measure 6 - "Jet-Ice" System for Ice

Energy Calculations - continued

d) Energy use for flooding (in arena)

The ice arena is used approximately 2400 hours per season. Assuming 1 flood after every 2 hours use with 90 US gal. of water per flood at 140°F the energy needed is:

$$\text{C-10:}\quad \frac{\left(\frac{2400}{2} \times 90\ \frac{\text{US gal}}{\text{yr}}\right) \times (140 - 40) \times 8.33}{35313 \times .70} = 3639\text{m}^3/\text{yr}.$$

Assume energy for heating initial floods and pebbling etc. is negligible.

Thus the energy consumed by the ice plant system (not including indirect heating costs) is:

Electricity	927090 kWhrs	$25,217
Gas	3639m^3	507
Demand	238 KVA for 9 months	
Total demand	2142 KVA per year	20,820
		$46,544

Savings From Jet Ice

Jet ice is reputed to save 23% of the refrigeration plant ice time*. This is made possible by operating the ice at a higher temperature and with reduced ice thickness as the jet ice is a harder ice surface.

Thus savings due to reduced operation of compressors are:

a)	Compressors	437760 kWhrs x 23% =	100684 kWhrs.
b)	Pumps	no reduction	nil
c)	Condenser	52530 kWhrs x 23% =	12082 kWhrs.
	Total		112766 kWhrs.

* Borough of Scarborough Energy Savings Report on Jet Ice.

Additional savings are due to reduced ice flooding. Assume flooding done once every 3 hours and only 50 gal. of water per flood.

$$(3639) - \frac{\left(\frac{2400}{3} \times 50\right) \times (140 - 40) \times 8.33}{35313 \times .70} = 2291\text{m}^3$$

2. TECHNICAL ANALYSIS - continued

2.6 Measure 6 - "Jet-Ice" System for Ice

Energy Calculations - continued

Savings From Jet Ice - continued

d) continued

In addition to the above savings, there are the indirect savings in heating costs for the arena and curling which will result from raising the ice temperature.

For the arena, assuming an indoor temperature of 40°F and an ice surface temperature of 5°F higher with jet ice the savings are approximated by:

C-11: $\frac{17000 \text{ SF} \times 0.25 \times 5 \times 5100}{35313 \times .70} = 4384\text{m}^3$ convective load

Assume ceiling temperatures are 20° above room temperature and ice temperature are raised from 22°F to 27°F.

C-11: $0.1713 \times 17000 \times 0.90 \times \left[\frac{(27 + 459.67)}{100} \right]^4 - \left[\frac{(22 + 459.67)}{100} \right]^4$

= 50495 BTU's
Gas savings due to radiant loads are therefore

$\frac{59495 \times 5100}{35313 \times .70}$ hrs. = 12275m^3

For curling, assuming an indoor temperature of 35°F and an ice surface temperature of 5°F higher with jet ice, the savings are approximated by:

C-11: $\frac{17280 \times 0.25 \times 5 \times 3637}{3410}$ = 23038 kWhrs convective load

For the radiant load assuming ceiling temperatures are 20°F above room temperatures and ice temperatures are raised from 25°F to 30°F.

C-11: $0.1713 \times 17280 \times 0.90 \left[\frac{(30 + 459.67)}{100} \right]^4 \frac{(25 + 459.67)}{100}^4]$

= 61607 BTU's

Electrical savings due to radiant loads are therefore:

$\frac{61607 \text{ BTU's} \times 3637}{3410}$ = 65708 kWhrs/yr

2. TECHNICAL ANALYSIS - continued

2.6 Measure 6 - "Jet-Ice System for Ice - continued

Energy Calculations - continued

Thus total savings for installation of the jet-ice system are:

Electrical Consumption	112756 + 23038 + 65708 = 201502 kWhrs	= $5481/year
Electrical Demand	nil	
Gas Consumption	2291 + 4384 + 12275 = 18950m^3	= $2642/year
Total		397745 EKWH $8123/year (4.5 EKWH/SF/yr)

If heat recovery is implemented the savings due to reduced heating and DHW heating are reduced by 50% resulting in the following net savings.

Electrical Consumption	112766 kWhrs.	=	3067/yr
Gas Consumption	12564m^3	=	1751/yr
Total	(2.7 EKWH/ft^2/yr)		$4818/yr

Note: In addition to heat recovery the curling is switched from electrical heating to gas heat.

2. TECHNICAL ANAYLSIS - continued

2.7 Measure 7 - Heat Recovery from Ice Machine

Situation - Ice is produced in the arena via a 100 ton ammonia ice plant which throws away up to 6.6 billion BTU's of heat every year. In other words 20% of the buildings annual energy use is thrown away.

Solution: The source report recommended the installation of both high temperature de-superheat and low temperature heat recovery devices.

The high temperature heat recovery devices were to consist of two "Therma-stor" heat exchangers, each with a capacity of 100,000 BTUH. The high temperature heat exchangers would recover heat at approximately 180°F for use in ice flooding, showers and general domestic hot water use throughout the building.

The low temperature heat would be reclaimed via a special cupronickel heat exchanger to heat the swimming pool, the curling rink space, the change rooms in the arena and the arena space.

The existing heating systems would remain in place to provide back-up to the reclaimed heat.

The design solution chosen initially utilized three high temperature "Therma-stor" heat exchangers. Two of the heat exchangers were used to recover heat for domestic hot water. The third was used to recover heat for the "jet-ice" flood water. One of the domestic hot water heat exchangers was removed from the design during price negotiations to reduce costs.

With the implementation of the dehumidification system in the pool, the need for a heat recovery in the pool was eliminated, therefore a cupronickel heat exchanger was no longer required. Although the dehumidifier for the pool was not constructed, this decision was not changed.

Low temperature heat was therefore recovered via a standard shell and tube condenser to a low temperature glycol system for use in space heating. To maximize the temperature of this recovered heat, condensing temperatures were set at 105°F and the glycol solution supply temperature was set at 90°F.

Heat delivery to the spaces was to be via unit heaters or air heating coils. In order to use 90°F glycol for space heating all selected equipment had to be derated. Thus for space temperatures of 70°F the equipment had to be chosen 10 times larger than the usual size and for space temperatures of 35°F the equipment was 3 times normally sized equipment.

2. TECHNICAL ANAYLSIS - continued

2.7 Measure 7 - Heat Recovery from Ice Machine - continued

Solution - continued

With the above derating it becomes impractical to heat the dressing rooms directly, thus the dressing room hallways were heated instead, reducing the load on the dressing room electrical heaters.

In order to properly heat the dressing room hallways new doors were added to separate the hallways from the arena.

The main entrances to the arena (rampway) are heated with electric heaters. Heating of the rampway was added to the low temperature heat recovery system.

With the addition of the jet-ice system an additional water heater was required to heat the flood waters. It was decided to enlarge this heater and to utilize this enlarged heater to provide back-up heating for heat recovery space heating systems and to indirectly provide for heating of the jet-ice waters. This system was installed .

With the above heater the existing electrical unit heaters in the curling and rampway could be deleted with a resulting saving in building electrical demand costs, as well as guaranteeing that auxillary energy used by these areas was created using lower priced natural gas.

2. TECHNICAL ANALYSIS - continued

2.7 Measure 7 - Heat Recovery From Ice Machine - continued

Energy Calculations

Amount of Heat Available

Each compressor has a capacity of about 50 TONS and uses a 75HP motor. Thus each compressor has a heat rejection of about 800,000 BTUH, 15% of which is high temperature heat.

The ice plant is assumed to operate as follows:

Month	Lead Comp. (Hrs./Mo.)	Lag Comp. (Hrs./Mo.)	High Temp. Heat Avail.	Low Temp Heat Avail.	Total Heat Available
				(x 10^6 BTU)	
July	0	0	0	0	0
Aug.	744	744	178.6	1011.8	1190.4
Sept.	720	504	146.9	832.3	979.2
Oct.	744	364	133.0	753.4	886.4
Nov.	720	164	106.1	601.1	707.2
Dec.	648	60	85.0	481.4	566.4
Jan.	583	30	73.6	416.8	490.4
Feb.	605	40	77.4	438.6	516.0
Mar.	744	164	109.0	617.4	726.4
Apr.	360	288	77.8	440.6	518.4
May	0	0	0	0	0
June	0	0	0	0	0
Total	5868	2358	987.4	5593.4	6580.8

Full load hours 4113

Additionally it is assumed that the lag compressor operates in the occupied hours only.

2. TECHNICAL ANALYSIS - continued

2.7 Measure 7 - Heat Recovery From Ice Machine - continued

Energy Calculations - continued

Amount of Heat Used

Space heating requirement for the various areas are shown on a month by month basis. Calculations were done for each area using calculation C-4.

	Curling (MWH)	Rampway (MWH	Ice Arena (m^3)	Change Rooms Total (MWH)	Change Rooms Arena Portion (MWH)
July	0	0	0	0	0
Aug.	0	0	0	40.1	40.1
Sept.	0	0	6572	42.2	38.8
Oct.	752.2	0	8959	46.7	40.1
Nov.	780.6	0.1	12498	50.1	38.8
Dec.	934.6	2.2	15679	55.5	40.1
Jan.	1008.5	2.9	17257	57.6	40.1
Feb.	869.8	2.5	14701	50.8	36.2
Mar.	843.1	0	13700	53.0	40.1
Apr.	253.1	0	9250	45.9	38.8
May	0	0	16	27.7	19.4
June	0	0	0	0	0
	5441.9	7.7	98632	469.6	372.5
Room temperature	35°F	45°F	40°F	70°F	60°F

Domestic Hot Water Requirements

Based upon a fixture count and tables 1, 6, 7 and 13 of ASHRAE - 1980 - Chapter 37, the domestic hot water load is estimated to be as follows:

	GPH	MBH
Standby Loss	0	46
Average 24 load	225	234
Average 12 hour load	450	421
Peak 1 hour load	3400	2546

2. TECHNICAL ANALYSIS - continued

2.7 Measure 7 - Heat Recovery From Ice Machine - continued

Domestic Hot Water Requirements - continued

Domestic hot water use is assumed to be constant all year except for the summer 2 months, thus gas consumption for domestic hot water is assumed as follows: (ice flooding is from Measure 6)

	Peak (MBH)	DHW Gas Consumption (m^3)	Ice Flood Gas Consumption (m^3)	Total (m^3)
January	991	9102	437	9539
February	991	9102	395	9497
March	991	8343	437	8780
April	991	7584	212	7796
May	991	6447	-	6447
June	400	4550	-	4550
July	400	4550	-	4550
August	991	6447	437	6884
Sept.	991	7584	473	8007
Oct.	991	9102	437	9539
Nov.	991	9102	423	9525
Dec.	991	9102	437	9539
Total		91015	3638m^3	94653m^3

Table 2.2 summarizes the available superheat and the domestic hot water heat requirements using 1, 2 and 3 "Therma-stor" tanks.

2. TECHNICAL ANALYSIS - continued

TABLE 2.2 - HIGH TEMPERATURE HEAT RECOVERY (x 10^6 BTU)

	Available Superheat	Energy Needed Dom. Hot Water	Ice Flooding	Energy Saved 1 Therma-stor	2 Therma-stor	2 & 1 Therma-stors
July	0	104.4	0	0	0	0
Aug.	178.6	148.0	9.0	54.3	91.5	100.5
Sept.	146.9	174.1	8.7	52.6	88.6	97.3
Oct.	133.0	208.9	9.0	54.3	91.5	100.9
Nov.	106.1	208.9	8.7	52.6	76.2	84.9
Dec.	85.0	208.9	9.0	49.9	63.3	72.3
Jan.	73.6	208.9	9.0	46.9	57.3	66.3
Feb.	77.4	208.9	8.1	46.0	56.7	64.8
Mar.	109.0	191.5	9.0	54.3	78.4	87.4
Apr.	77.8	174.1	8.7	26.3	44.3	53.0
May	0	148.0	4.3	0	0	0
June	0	104.4	0	0	0	0
Total	987.4	2090.0	83.2	437.2	647.8	727.4
Peak Load	240 MBH	991.9 MBH	500 MBH	100 MBH	200 MBH	200 & 100 MBH
Ave. 24 hr. Load	159.4 MBH	263.7 MBH	13.4 MBH			
Ave. 12 hr. Load	198.8 MBH	481.5 MBH	26.8 MBH			

Note: At night when there is domestic hot water use only 46 MBH can be saved. During day peak saving average 100, 200 or 300 MBH depending upon number of therma-stors.

2. TECHNICAL ANALYSIS - continued

2.7 Measure 7 - Heat Recovery From Ice Machine - continued

Energy Calculations - continued

Therefore savings are as follows:

First domestic hot water therma-stor	437.2 MMBTU	= 19,047m³	= $2,762/yr
Second domestic hot water therma-stor	210.6 MMBTU	= 9,176m³	= 1,330/yr
Jet-ice therma-stor	79.6 MMBTU	= 3,668m³	= 503/yr

Energy available to reduced heating is summarized in Table 2.3.

2. TECHNIAL ANALYSIS - continued

TABLE 2.3 LOW TEMPERATURE HEAT RECOVERY

	Available* Energy x 10^6 BTU	Heat Used x 10^6 BTU Curling	Ramping	Arena**	Change Room***	Total
July	0	0	0	0	0	0
August	1,089.9	0	0	0	136.7	136.7
September	881.9	0	0	162.5	143.9	306.4
October	785.5	256.4	0	221.5	159.3	637.2
November	622.3	266.3	0.3	308.9	170.8	746.3
December	494.1	318.7	7.5	387.6	189.3	903.1
January	414.1	343.9	9.9	426.6	196.4	976.8
February	451.2	296.6	8.5	363.4	173.2	841.7
March	639.0	287.5	0	338.7	180.7	806.9
April	465.4	86.3	0	228.7	156.5	571.5
May	0	0	0	0.4	94.5	94.9
June	0	0	0	0	0	0
Total	5,853.4	1855.7	26.2	2,438.3	1,601.3	6,021.5

* Assumes 3 therma-stors in operation remainder of heat is available for recovery.

** The arena has a maximum heat recovery rate of 266 MBH due to limitation on feasible heating coil sizes. Thus its energy savings are also limited.

***Since the changerooms are not being heated directly only the portion of heating that is caused by the arena can be reduced. The hallway is assumed to be heated to 60°F thus savings are 2/3 of the arena load.

2. TECHNICAL ANALYSIS - continued

2.7 Measure 7 - Heat Recovery From Ice Machine - continued

Energy Calculations - continued

Table 2.4 summarizes the quantity of heat that is available for recovery and the amount of heat that is required for heating. Note that the total amount of heat available is more than what is required by the complex, thus theoretically with an energy storage system the building would not require any additional energy or space heating.

There is no storage system in the system, therefore not all the heat will be recovered. Table 2.5 summarizes the peak loads predicted for the system. Note that the peak heating requirements occur at night while peak available heat occurs during the day.

2. TECHNICAL ANALYSIS - continued

TABLE 2.4 MAXIMUM ENERGY SAVED DUE TO LIMITATION OF ENERGY REDUCED HEATING (x 10^6 BTU's)

	Available Heat	Curling	Rampway	Arena	Change Rooms	Maximum Heat Saved
July	0	0	0	0	0	0
August	1,089.9	0	0	0	91.2	91.2
September	881.9	0	0	162.5	88.2	250.7
October	785.5	256.4	0	197.9	91.2	545.5
November	622.3	266.3	0.3	191.5	88.2	546.3
December	494.1	318.7	7.5	197.9	91.2	615.3
January	429.1	343.9	9.9	197.9	91.2	642.9
February	451.2	296.6	8.5	178.8	82.3	566.2
March	639.0	287.5	0	197.9	91.2	576.6
April	465.4	86.3	0	191.5	88.2	366.0
May	0	0	0	0.4	44.1	44.5
June	0	0	0	0	0	0
Total	5,853.4	1,855.7	26.2	1,353.8	846.8	4,245.2

TABLE 2.5 PEAK HEATING & RECOVERABLE HEAT

	Available Average Peak Loads (MBH)		Available Average Peak Loads Less De-superheating 3 Tanks Installed (MBH)		Required Heating (MBH)	
	Day	Night	Day	Night	Day	Night
July	0	0	0	0	0	0
August	1600.0	1600.0	1375.8	1554.0	102.2	147.1
Sept.	1600.0	1120.0	1375.8	1074.0	336.9	413.0
Oct.	1582.8	800.0	1358.6	754.0	655.3	826.6
Nov.	1164.4	800.0	974.6	754.0	676.6	857.3
Dec.	929.0	593.5	768.8	559.4	733.5	939.2
Jan.	864.5	453.8	712.4	427.7	764.4	983.7
Feb.	895.2	640.5	739.2	603.7	746.4	957.8
Mar.	1152.7	800.0	963.8	754.0	690.2	876.8
Apr.	1440.0	800.0	1191.6	754.0	669.9	847.7
May	0	0	0	0	0	0
June	0	0	0	0	0	0

Note: During the day, the ice plant's heat rejection is highest. Heating at night is assumed to be 20% higher than average and during the day heating is assumed to be 20% lower than average.

2. TECHNICAL ANALYSIS - continued

2.7 Measure 7 - Heat Recovery From Ice Machine - continued

Energy Calculations - continued

Thus using the data in Tables 2.4 and 2.5 the average recoverable heat is available as follows:

	Available Heat ($\times 10^6$ BTU's)		Auxiliary Heat		Waste Heat	
	Day	Night	Day	Night	Day	Night
July	0	0	0	0	0	0
August	102.2	147.1	0	0	1273.6	1406.9
Sept.	336.9	413.0	0	0	1038.9	666.0
Oct.	655.3	754.0	0	72.6	703.3	0
Nov.	676.6	754.0	0	103.3	298.0	0
Dec.	733.5	559.4	0	379.8	35.3	0
Jan.	712.4	427.7	52.0	556.0	0	0
Feb.	739.2	603.7	7.2	354.1	0	0
Mar.	690.2	754.0	0	122.8	273.6	0
Apr.	669.9	754.0	0	93.7	521.7	0
May	0	0	0	0	0	0
June	0	0	0	0	0	0

Thus total recoverable heat is as follows:

($\times 10^6$ BTU's)

	Recovered Heat	Auxillary Heat	Waste Heat
July	0	0	0
August	92.7	0	997.1
September	270.0	0	613.8
October	524.3	27.0	261.6
November	515.0	37.2	107.3
December	481.0	141.3	13.1
January	424.1	226.2	0
February	451.2	121.4	0
March	537.2	45.7	101.8
April	256.2	16.9	93.9
May	0	0	0
June	0	0	0
Amount	3,551.7	615.7	2,188.6

2. TECHNICAL ANALYSIS - continued

2.7 Measure 7 - Heat Recovery From Ice Machine - continued

Energy Calculations - continued

Thus total energy savings are as follows:

	BEFORE		AFTER			
	Before	Demand KVA/Mo.	After Primary System	Backup System		Demand KVA Mo.
Curling	544.2 MWH	144	0	)		7
Rampway	7.7 MWH	60	0	)		2
Arena	98632m³	-	43869m³	)	24908m³	-
Change Rooms	469.6 MWH	133.5	97 MWH	)		133.5
Totals	1021.5 MWH 98632m³ 338 KVA per month x 9 months x 70% = 2129 KVA per year		97.0 MWH 68777m³ 143 KVA per month x 9 months x 80% = 1030 KVA per year			
Annual Costs						
Gas 13.94¢/m³	$13,749		$ 9,588			
Elec. 2.72¢/KVA	27,785		2,638			
& $9.72/KVA	20,694		10,012			
Total	$62,228/year		$22,233/year			

This heating savings are $39,955/year.

Total heating and domestic hot water saving with 3 therma-stors is $44,590/year.

2. TECHNICAL ANALYSIS - continued

2.8 Measure 8 - Replace Existing Thermostats With Night Set Back Thermostats

Situation - The convention floor of the arena is heated with a gas fired furnace. This thermostat for this area is kept at 70°F all year.

The concourse is similarly heated with a gas fired furnance and this thermostat is also kept at 70°F all year.

Solution - The source report recommended installing night set back thermostats in the above areas.

Upon review we did not proceed with these items as:

a) Neither of the furnaces is connected to an outside air duct. Therefore energy savings by night set back are nominal.

b) The convention centre is either badly air balanced (see Measure 9) or underheated as there is apparently difficulty in keeping the area warm enough. Night set back would aggravate this problem.

c) There is no typical time schedule for the convention area.

d) The areas are kept cool most of the time anyway.

An operation change was recommended to keep these thermostats constantly at low temperatures except on days of scheduled events.

2. TECHNICAL ANALYSIS - continued

2.9 Measure 9 - Air Balance HVAC Systems

Situation - The pool area is being pressurized with respect to the remainder of the complex. In addition the heating system in the convention centre does not work well.

Solution - The source report recommended an air balance be done to the fan systems in the convention/concourse area to rationalize these systems.

After review we have chosen to attempt the following with the air balance program.

1. Rebalance the convention centre air handler to ensure heat is delivered as designed. This will result in the heating system being able to properly heat the area making lowering of the area temperature possible during unoccupied time.

2. Reduce the amount of makeup air being supplied by the pool change room.

The ventilation system as originally designed was to provide the following air volumes:

	Supply Air (CFM)	Washroom Exhaust (CFM)	Kitchen Exhaust (CFM)	Other Exhaust (CFM)	Total Exhaust (CFM)
Pool Gallery	1000	-	-	800(1)	800
Change Rooms	3300	2400(1)	-	-	2400
Convention Centre	5000	400(2)	2100(3)	3000(4)	5500
Concourse	2000	500(2)	2400(5)	-	2950
Offices	1700	-	-	-	-
Curling Lounge	1200	400(6)	1500(7)	-	1900
Curling Lobby	1000	1000	-	-	1000
Total	15200	4750	6000	3800	14550

(1) FE #25 Pool Change Room Exhaust
(2) FE #18 Concourse/Convention Centre Washroom Exhaust
(3) FE #20 Convention Centre Kitchen Exhaust
(4) FE #16 & 17 Convention Centre General Exhausts
(5) FE #21 Concourse Kitchen Exhaust
(6) FE #19 Curling Lobby/Lounge Washroom Exhaust
(7) FE #22 Curling Lounge Kitchen Exhaust

2. TECHNICAL ANALYSIS - continued

2.9 Measure 9 - Air Balance HVAC Systems - continued

Solution - continued

In addition to the above 4 - rooftop cooling and ventilation units have been added to the convention centre (4 Carrier 48DP, EP005). Each unit supplies 2000 CFM of air with about 5 TONS of mechanical cooling. Two of the units are equipped with minimum fresh air dampers, the other two units have full economizers. Total outside air from the four units is assumed to be CFM (10%) when in operation. These units are only operated when an event is in progress in the convention centre.

The rebalancing included the following:

	Supply Air (CFM)	Washroom Exhaust (CFM)	Kitchen Exhaust (CFM)	Other Exhaust (CFM)	Total Exhaust (CFM)
Pool Gallery	1000	-	-	800	800
Change Rooms	3300	2400	-	-	2400
Convention Centre	-	400	2100	3000	5500
Concourse	-	550	2400	-	2950
Offices	106	-	-	-	-
Curling Lounge	406	400	1500	-	1900
Curling Lobby	500	1000	-	-	1000
Total	5306	4750	6000	3800	14550

In addition the following operational instructions sould be implemented:

FE #25	Shut off at night.
FE #18	Shut off at night.
FE #20	Shut off when kitchen is not used.
FE #16 & 17	Shut off except for brief periods during an event.
FE #21	Shut off when kitchen is not used.
FE #19	Shut off at night.
FE #21	Shut off when kitchen is not used.
MU #1	Shut off at night.

The net result of air balancing and the above operational changes is to reduce outside air makeup to the complex and to slightly increase air infiltration to the complex.

2. TECHNICAL ANALYSIS - continued

2.9 Measure 9 - Air Balance HVAC Systems - continued

Energy Calculations - Existing energy use required 15200 CFM of outside air to be heated to 70°F, 8760 hours per year. Energy use is estimated to have been:

C-2: $\frac{15200 \times 1.1 \times (70 - 35) \times 1 \times 1 \times 8760}{35313 \times 100\%} = 145169 m^3$ of gas

Some of the exhaust fans were shut off at night, but since the makeup air unit continued to run unchanged this analysis takes no credit for reduced air volumes.

By implementing the above measures total supply air volume is reduced to 5306 CFM and the makeup air unit is shut down for 8 hours per day.

Air volumes are assumed to act as follows in a normal 12 hour winter day.

	Supply Air	Exhaust	Notes	Infiltration CFM
Pool Gallery	1000	800	Excess air to convention centre.	0
Change Rooms	3300	2400	Excess air to pool.	0
Convention Centre	0	400		200
Concourse	0	550		444
Offices	106	0	Excess air to concourse.	0
Curling Lounge	400	400		0
Curling Lobby	500	1000		500
Total	5306	5550		1144

In addition for 4 hours per day the kitchen exhaust fans are assumed to be on as follows:

	Supply Air	Exhaust	Notes	Infiltration CFM
Pool Gallery	1000	800	Excess air to convention centre.	0
Change Room	3300	2400	Excess air to pool.	0
Convention Centre	0	2500		2300
Concourse	0	2950		2844
Offices	106	0	Excess air to concourse.	0
Curling Lounge	400	1900		1500
Curling Lobby	500	1000		500
Total	5306	11550		7144

2. TECHNICAL ANALYSIS - continued

2.9 Measure 9 - Air Balance HVAC Systems - continued

Energy Calculations - continued

Finally at night 8 hours per day all fans are shut off. Energy use is:

C-2: 12 hours/day $\frac{(5306 + 1144) \times 1.1 \times (70 - 35) \times 1 \times 1 \times 4380}{35313 \times 100\%} = 30800m^3$

C-2: 4 hours/day $\frac{(5306 + 7144) \times 1.1 \times (70 - 35) \times 1 \times 1 \times 1460}{35313 \times 100\%} = 19817m^3$

C-2: 8 hours/day 0

Total new energy use $50617m^3$

Energy saving (145160 - 50617) = $94543m^3$ of gas at 13.94¢ equals $13179/year.

2. TECHNICAL ANALYSIS - continued

2.10 Measure 10 - Lighting Modifications

Situation - The general areas of the complex are lit with incandescent lights. Incandescent lighting is the least efficient type of lighting source.

Solution

The source report recommended changing the incandescent lights to fluorescent lights and to provide increased switching. The following work was done:

a) 12-150 watt incandescent pot lights in the curling eating area were replaced with 3-100 watt fluorescent lights at a cost of $224.20.

b) 14-150 watt incandescent lights in the concourse areas were replaced with 6-100 watt fluorescent lights at a cost of $522.78.

c) 68-150 watt incandescent lights over the arena, bleachers changeroom hallways and zamboni room were changed to 18-200 watt fluorescents and 12-100 watt fluorescent lights at a cost of $3219.59.

d) 8 x 3-150 watt incandescent lights in the canopy were changed to 3-130 watt high pressure sodium lights at a cost of $1099.00.

Total cost was $5065.57.

Energy Calculations

a) Demand saving $\frac{12 \times 150 - 3 \times 100}{1000}$ = 1.5 KVA

Consumption 1.5 KVA x 2000 hours = 3000 kWhrs

b) Demand saving $\frac{14 \times 150 - 6 \times 100}{1000}$ = 1.5 KVA

Consumption 1.5 KVA x 4380 hours = 6570 kWhrs

c) Demand saving $\frac{68 \times 150 - 18 \times 200 - 12 \times 100}{1000}$ = 5.4 KVA

Consumption 5.4 KVA x 4380 hours = 23652 kWhrs

d) Demand saving $\frac{8 \times 3 \times 150 - 3 \times 130}{1000}$ = 3.2 KVA

Consumption 3.2 KVA x 4380 hours = 14016 kWhrs

2. TECHNICAL ANALYSIS - continued

Energy Calculations - continued

Total savings:

Demand 11.6 KVA x 12 months at $9.72 =	$1353
Consumption 47238 kWhrs at 2.72¢ =	$1285

Total $2638/year.

3. OWNERS RETROFIT

Yorkton's direct work on the facility is itemized in Section 1.1. The following is a summary of the action they have undertaken.

Measure a)

- Weatherstripping - The owner was to repair or add weatherstripping to all doors and operable windows.

- This work has been done.

Measure b) - Seal laminated beam/wall joints in pool area.

- The owner was to apply a sealant bead at these joints.

- This work has been done.

Measure c) - Replace hollow metal door in pool equipment room.

- This work has been done.

Measure d) - Install time clock to shut down pool washroom exhaust fans when unoccupied.

- This measure was done, however the makeup air unit still runs all of the time. The time clock should be interlocked to shut off the makeup air unit as well, see Measure 9.

Measure e) - Caulk around exhaust fan housings in arena.

Measure f) - Discontinue use of ice melt pit.

- The owner was to drive the zamboni out of the building and dump the snow outside. He is doing this in warmer weather only. During cold weather the opening of the doors cools the arena too much.

Measure g) - Discontinue use of arena entrance way heaters.

- These heaters were disconnected.

Measure h) - Install time clock to control curling rink temperature to 30°F when unoccupied.

- The owner was to arrange to have the heaters shut off at night. This measure was dropped with the incorporation of Measure 7 -- heat reclaim from the ice maker.

Measure i) - Install humidistat to control curling rink exhaust fans.

- This measure was dropped as the curling rink exhaust fans are normally off. In addition, humidistat controls seldom work properly.

4. MONITORING PROGRAM

The purpose of the monitoring program is to confirm the savings estimated in this report and the source report are actually achieved. This will confirm the calculation methodology and in doing so the project's economics will be demonstrated.

To date there has been no monitoring of the building other than SPC's gas and electric meters.

The building is currently estimated to use about 86 EKWH/SF/Yr. Table 4.1 summarizes the expected energy reductions.

The recommended monitoring program is as follows:

Overall Program Effectiveness

In order to demonstrate the overall savings due to the measures taken, weekly readings should be taken of:

- existing SPC gas meter
- existing SPC electric meter (kWhrs)
- existing SPC electric meter (KVA)

A graph of these readings when plotted against weather data will indicate if the overall programm results are achieved.

4. MONITORING PROGRARM - continued

TABLE 4.1 - SUMMARY OF ENERGY CONSERVATION MEASURES

Measure	Description	Gas (m^3)	Percent Change	Electricity (kWhrs)	Percent Change	Electricity (KVA)	Percent Change
	Current energy use.	447800	-	2863900	-	6528	-
	Range of energy use.	±24700	± 5.6%	±206200	± 7.2%	±287	± 4.4%
1	Destratification fans						
	- pool	-3694	- 0.8%	-	-	-	-
	- arena	-34185	- 7.6%	-112264	- 3.9%	-	-
	- curling	-13427	- 2.9%	-39777	- 1.4%	-	-
3	Pool Lighting	-	-	-5694	- 0.2%	-16	- 0.2%
4	Change Room Exhaust Fans	-302	- 0.1%	-4575	- 0.2%	-	-
5	Change Room Night Set-back	-	-	-	-	-402	- 6.2%
7	Heat Recovery						
	- domestic hot water	-19047	- 4.3%	-	-	-	-
	- flood water	-3668	- 0.8%	-	-	-	-
	- heating	-29855	- 6.7%	-924500	-32.3%	-1099	-16.8%
9	Air Balance Systems	-94543	-	-	-	-	-
10	Lighting Modifications	-	-	-47238	- 1.6%	-139	- 2.1%
	Total Savings	-198721	-44.4%	-1134048	-39.6%	-1656	-25.4%
	Expected Energy Use	249079		1729852		4872	

4. MONITORING PROGRAM - continued

Measure 1 - Destratification Fans

There is no specific monitoring that will isolate the effect of the destratification fans. Instead a test must be done to demonstrate their effectiveness.

The test should be conducted as follows:

Week	Pool Fans	Curling Fans	Ice Arena Fans
1	On	On	On
2	On	Off	On
3	Off	Off	On
4	On	Off	Off
5	On	On	On

etc.

This type of pattern continues to have at least 8 on/off readings of each area.

This test should be conducted for a period of at least 16 weeks during the fall to winter transition.

During the test period the following instrumentation should be recorded weekly.

- existing main SPC gas meter
- existing main SPC electric meter kWhrs.
- existing main SPC demand meter (KVA)
- existing ice plant compressor #1 run time meter
- existing ice plant compressor #2 run time meter
- new pool gas meter (to isolate VU-1 and the pool boilers)

In addition the weekly report should contain observations on ice temperature and room temperature and problems.

The above data can then be plotted against the average weekly temperature and the affect of destratification fans can be isolated for each area.

Measure 3 - Pool Lighting

To confirm assumptions made on the pool lighting a new run timer could be installed to confirm the hours of operation of the lights, however the savings are small, this measure should likely be ignored in the monitoring program.

4. MONITORING PROGRARM - continued

Measure 4 - Change Room Exhaust Fans

To confirm the assumptions made for the change room exhaust fans, a run timer should be installed to record their operation. In addition a weekly report on time clock setpoints would be required.

Measure 5 - Change Room Nite Setback

To confirm assumptions made for the change rooms a kWhr meter should be installed for each change room wing. In addition the setting to the time clock and duty cycler should be recorded weekly.

Measure 7 - Heat Reclaim

In order to confirm assumptions made in this analysis and to record the heat recovered from the system the following instrumentation is recommended. (read weekly:)

- Existing run time meter on ice plant comp. #1
- Existing run time meter on ice plant comp. #2
- Existing SPC gas meter
- Existing SPC electric meter
- Existing SPC electric demand meter
- New gas meter on new hot water boiler
- New gas meter on existing domestic hot water heater
- New water meter on domestic hot water usage
- New water meter on ice flood water usage
- New Btu meter on "Therma-stor" #1
- New Btu meter on "Therma-stor" #2
- New Btu meter on low temperature heat recovery condenser
- New Btu meter on ice flood water heat exchanger

In addition with the weekly readings observations should be reported

- room temperature setpoints
- ice temperature setpoints
- status of anti-stratification fans
- domestic hot water temperature
- ice flood water temperature

The above data will isolate the major variables affecting the system.

Measure 9 - Air Balance

To assure the makeup air system is operated in accordance with the assumptions made in the report, the following instrumentation should be read weekly:

4. MONITORING PROGRAM - continued

Measure 9 - Air Balance - continued

New run time meter on MU-1	Makeup air unit
New run time meter on FE-16	General Exhaust - Convention Centre
New run time meter on FE-17	General Exhaust - Convention Centre
New run time meter on FE-18	Washroom Exhaust Convention Centre
New run time meter on FE-20	Convention Kitchen Exhaust
New run time meter on FE-21	Concourse Kitchen Exhaust
New run time meter on FE-25	Curling Kitchen Exhaust

In addition, observations should be made on

- setting of time clocks
- problems

Measure 10 - Upgrade Lighting

To confirm assumptions made on upgrade lighting, would require several run time meters or kWhr. meters scattered throughout the building. As the savings are small these meters are likely not justified.

Summary

The following instrumentation and reports recorded weekly is required to measure the results of the Phase II program.

Existing SPC gas meter
Existing SPC electric meter (kWhrs)
Existing SPC demand meter (KVA)
Existing SPC Ice Plant #1 run time meter
Existing SPC Ice Plant #2 run time meter
3 - New gas meters
2 - New run time meters
2 - New electricity meters (kWhrs)
4 - New BTU meters
2 - New water meters
- 16 week destratification fan test
- Status reports

5. CONCLUSION & RECOMMENDATIONS

Table 5.1 contains a summary of all measures implemented under this program.

Measure - 2 - The pool dehumidifier was tendered and came in at a cost of about $100,000. As the total construction cost of the project was exceeding the budget, this measure had to be dropped from construction.

Measure - 6 was also dropped from this phase of construction to control overall capital costs. The cost for "jet-ice" is approximately $30,000. The owner plans to install it on his own in the near future.

Measure - 8 was not done as it was impractical to proceed with.

All the remaining measures were done and for a total cost of $282,279 the annual savings are estimated to be $74,671/year resulting in a 3.8 year simple payback.

TABLE 5.1 YORKTON PARKLAND AGRIPLEX

MEASURE		BUDGETED COST	BUDGETED SAVINGS	ACTUAL COSTS	ANNUAL SAVINGS	PAYBACK PERIOD
1	Install destratification fans - curling rink.	$ 9,400	$ 9,500	$ 12,309	$ 11,286	1.1 years
3	Replace incandescent fixtures with fluorescent in pool area and pool gallery.	$ 1,800	$ 450	$ 375	$ 307	1.2 years
4	Install time clock to shut down arena change room exhaust fans during unoccupied periods.	$ 300		$ 507	$ 108	4.7 years
5	Install time clock and night setback thermostat to set back temperatures in arena change rooms during unoccupied periods. (Only duty cycling implemented.)	$ 500		$ 1,523	$ 3,893	0.4 years
7	Install heat recovery equipment to reclaim chiller waste heat to heat DHW, pool, curling rink, change room and arena.	$105,000	$ 20,500	$259,900	$ 43,260	6.0 years
9	Air balance all HVAC systems.	$ 5,000	$ 1,250	$ 2,600	$ 13,179	0.2 years
10	Lighting modifications for improved efficiency.	$ 5,000	$ 1,250	$ 5,065	$ 2,638	1.9 years
	Contingency	$156,432				
	TOTAL	$283,432	$ 32,950	$282,279	$ 74,671	3.8 years

APPENDIX I

GLOSSARY

GLOSSARY

BTU - British Thermal Unit, quantity of heat

BTUH - BTU's per hour, rate of heat transfer

CFM - Cubic feet per minute, air volume flow rate

CFH - Cubic feet per hour, air volume flow rate

DHW - Domestic hot water

EKWH - Equivalent kilowatt-hours, expresses a natural gas load in terms of kilowatt-hours based on equal energy units

EMWH - Equivalent mega-watt hours, EKWH divided by a 1000

fi & fo - Surface resistance to heat transfer of a horizontal or vertical surface. Subcript "i" refers to an inside surface, still air. Subscript "o" refers to an external surface with moving air blowing over the surface.

GPH - Gallons per hour in US gallons

GPM - Gallons per minute in US gallons

kWhr - Kilowatt-hours. Electrical energy consumption

MWhr - Mega-watt hours. kWhr divided by 1000

KVA - kilo-volt-amps. Measurement of electrical demand. KVA = kWhr/PF

MBTU - Thousands of BTU's

MBH - Thousands of BTUH's

MAT - Mixed air temperature

m^3 - Cubic meters

PF - Power factor

psig - Pounds per square inch gauge, pressure

R-value - Resistance to heat flow

U-value - Heat transfer coefficient of a surface

U-Value is the reverse of R-value

UA - U-value times area of surface

APPENDIX III

FUEL COSTS & HISTORIC FUEL BILLS

Current Utility Rate

Gas - General Service III effective July 9, 1983.

Basic monthly charge $ 7.06
Energy charge 12.67¢/m^3
Plus 10% estimated rate increase for 1984

Electricity - General Service IV effective July 9, 1983

Minimum monthly charge $573.75
Energy charge 2.14¢/KWatt hour
Demand charge $ 7.65/KVA
Plus 10% municipal surcharge
Plus 5% health and education tax
Plus 10% estimated rate increase for 1984

Marginal Costs

For the purposes of this report the following marginal costs are assumed.

Gas - 13.94¢/m^3
Elec. - 2.72¢/kWhrs.
- $9.72/KVA

Historical Gas Consumption (x1000m^3)

	1980[1]	1981[1]	1982[2]	1983[3]	Average
January	76.3	88.2	93.3	52.4	77.6
February	64.6	50.8	67.9	51.5	58.7
March	80.4		59.2	56.4	65.3
April	53.5		34.6	42.8	43.6
May	13.6		15.6	25.0	18.1
June	17.7		12.5	12.3	14.2
July	12.7		5.3	6.9	8.3
August	9.0	20.1	5.4	12.7	11.8
September	15.7	9.8	17.7	25.9	17.3
October	19.0	17.2	22.5	34.9	23.4
November	37.2	35.5	62.7		45.2
December	68.3	52.0	72.7		64.3
Annual	468.0	423.1[3]	469.4	430.3[3]	447.8

1 From Source Report
2 Consumption normalized to month
3 1981 total assumes average consumption
4 1983 total use assume November and December average

Average consumption 447800m^3 x 35313/3410 = 4637291EKWH

Historical Electrical Consumption (MWH)

	1980*	1981*	1982**	1983**	Average
January	484.8	478.1	489.7	268.9	430.4
February	378.2	289.9	328.3	304.4	325.2
March	459.8	380.2	335.9	341.0	379.2
April	375.4	293.8	213.4	217.7	275.1
May	69.1	144.0	100.8	84.0	99.5
June	67.2	79.7	89.8	81.5	79.6
July	73.9	79.7	52.6	80.6	71.7
August	50.9	50.9	112.1	255.7	117.4
September	141.1	108.5	157.9	160.6	142.0
October	207.4	180.5	170.2	252.5	202.7
November	406.1	325.4	363.6		365.0
December	356.2	353.3	418.8		376.1
Annual	3070.1	2763.8	2833.1	2788.0	2863.9

* From Source Report
** Consumption normalized to month
*** 1983 total assumes November and December are average

Historical Electrical Demand (KVA)

	1980	1981	1982	1983	Average
January	768.0	768.0	844.8	729.6	777.6
February	806.4	768.0	825.6	691.2	772.8
March	768.0	787.2	729.6	672.0	739.2
April	768.0	652.8	595.2	537.6	638.4
May	288.0	537.6	384.0	211.2	355.2
June	288.0	249.6	249.6	230.4	254.4
July	192.0	249.6	249.6	336.0	256.8
August	192.0	249.6	403.2	489.6	333.6
September	403.2	364.8	403.2	556.8	432.0
October	518.4	499.2	652.2	614.4	571.1
November	663.6	614.4	739.2		672.4
December	768.0	691.2	748.2		735.8
Average Month	535.3	536.0	567.9	539.8*	544.2
Peak Month	806.4	787.2	844.8	729.6	777.6

* 1983 annual average assumes November and December are average.

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